**SPECTRUM MANAGEMENT AND THE
GLOBAL POSITIONING SYSTEM: A CASE
STUDY IN INTERAGENCY COORDINATION**

THESIS

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Acknowledgments

Table of Contents

# List of Figures

# List of Tables

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Abstract

At the 2000 World Radio Conference (WRC), a European initiative resulted in the approval of resolutions 605 and 606 (agenda item 1.15), which the United States opposed. These resolutions established provisional power flux density (PFD) limits on the L2 and L5 frequencies of the Global Positioning System. These limits will negatively affect the $1.2B GPS modernization.

The United States will have to present its positions and rationale regarding the PFD limits to international meetings, including the 2003 World Radio Conference, to persuade the international community to adopt the U.S. view. Developing the U.S. view and conducting the supporting technical work for the World Radio Conference is accomplished through a domestic interagency U.S. process called the International Telecommunications Advisory Committee (ITAC) process. In this process, the interests and efforts of numerous agencies must be coordinated to produce a focused and cohesive argument. Accomplishing this is not easy. In fact, several players in the ITAC process working issues surrounding WRC resolutions 605 and 606 have encountered considerable difficulty reaching agreement and submitting technical contributions internationally.

An analysis of the ITAC process using coordination theory reveals that the problem stems from coequal participants attempting to coordinate directly conflicting interests in a consensus-based process. The problem is further complicated by the geographic separation of the parties. Several remedial actions are available, including using a third-party to arbitrate directly conflicting issues and co-locating the parties.

# SPECTRUM MANAGEMENT AND THE GLOBAL POSITIONING SYSTEM: A CASE STUDY IN INTERAGENCY COORDINATION

## I.    Introduction

**Background**

At the 2000 World Radio Conference (WRC), a European initiative resulted in the approval of resolutions 605 and 606 (agenda item 1.15), which the United States opposed (Schoettler, 2000: 48, 49).  These resolutions established the need to consider power flux density (PFD) limits on the L2 and L5 frequencies of the Global Positioning System (Delegation Report, 2000: 48, 50), as well as future Radio Navigation Satellite Systems (RNSS).  GPS satellites transmit navigation data to the GPS receivers on the L2 and L5 bands.  The resolutions passed at WRC-2000 place provisional limits on the power of the satellite transmissions.  The limits are based upon the theory that GPS Satellite transmissions can interfere with Radars and Distance Measuring Equipments (DME's), which have been allocated in the L2 and L5 bands prior to radio navigation satellite systems (RNSS).

These limits will directly affect the $1.2B GPS modernization and are undesirable to the United States for several reasons.  U.S. forces depend upon GPS technology, and the successful jamming of current and weaker GPS signals would be harmful to U.S. operations, and could place U.S. troops at risk.  The PFD limits restrict the power of GPS signals, and therefore increase the system's susceptibility to jamming and inadvertent interference.  Once international rules on power restrictions become permanent, changes

to these rules will require international agreement. If the restrictions could not be lifted, the system's development would be constrained.

The Global Positioning System Joint Program office has taken action to protect the GPS spectrum. These actions, including conducting technical studies, simulations, and tests, provide the technical and engineering arguments that ensure unnecessary restrictions are not imposed (Department of the Air Force WRC-03 Plan). The U.S. position for Resolution 605 is a coordination method whereby the RNSS operators will coordinate to provide protection to incumbent systems and retain the flexibility to modernize and build future RNSS systems. The U.S. position for Resolution 606 is that no PFD limit is needed (U.S. Preliminary View). The results of the technical studies and tests are presented internationally in ITU forums and other venues to support the U.S. position. In order to submit papers internationally, they must be domestically coordinated and approved through an interagency government process.

"The activities of the ITU [(International Telecommunications Union)], including the [World Radio Conferences], offer the United States an important opportunity to advance its views on technical standards and regulations" (U.S. Congress, Office of Technology Assessment, 1991: 14). It is at these ITU meetings and the World Radio Conference that the United States will have to present its arguments and persuade the international community to adopt the U.S. view.

Developing the U.S. view and supporting technical work is accomplished through a domestic interagency U.S. process called the International Telecommunications Advisory Committee (ITAC) process. The interests and efforts of numerous agencies

must be coordinated to produce a focused and cohesive argument. Accomplishing this is not easy.

Establishing and maintaining a successful interagency coordination program is extremely difficult (Rogers, 1982: 5). Individuals attempting to orchestrate inter-organizational coordination face problems ranging from communication to fragmentation of authority (Rogers, 1982: 66). The ITAC process and preparations for the 2003 World Radio Conference is no different. Producing a focused and cohesive supported position on GPS from the diverse interests in the United States has been and continues to be challenging.

**Problem Statement**

The Global Positioning System Joint Program Office has been having difficulty gaining domestic approval to submit the results of technical analyses performed related to WRC resolutions 605 and 606 internationally. This difficulty stems from the apparent divergent perspectives and interests within the U.S. government interacting within the International Telecommunication Advisory Committee Process (ITAC).

This technical, bureaucratic, and political conflict risks delaying or weakening defense of U.S. spectrum in the international arena. Bureaucratic conflict in which the solution is the product of an interagency power struggle and not based solely on the overriding national interest can cause significant harm to U.S. interests in the Global Positioning System Program. The U.S. government must act with a consistent voice to protect its interests abroad, and in doing so form and support its positions with a unified objective in mind.

**Research Question**

This study examined the domestic spectrum management process surrounding World Radio Conference resolutions 605 and 606. This study analyzed the International Telecommunication Advisory Process, with an emphasis on the approval process for technical contributions. This study identified problem areas, and recommended alternatives to improve the process. Improving this domestic process will help the U.S. more effectively defend its interests internationally.

**Methodology**

The methodology was a single-case study design (Yin, 1984) analyzing GPS spectrum management pertaining to WRC resolutions 605 and 606 issues. The spectrum management process involves many agencies and organizations throughout the U.S. government. This process provides an opportunity to assess a specific example of interagency coordination, and help the Global Positioning System Program in the process. The process will be analyzed using coordination theory.

**Thesis Organization**

This thesis is organized in five chapters. Each chapter covers a different focus on the topic. Readers only interested in the analysis and results should focus on chapters four and five. The theory and method are described in chapters two and three.

## II.    Literature Review

**Coordination Theory**

Coordination theory provides a framework for analyzing the management of interdependencies between organizations.  Coordination theory is a basis upon which coordination failures can be identified and alternative approaches generated.  In this instance, coordination theory will be used to analyze how the GPS Joint Program Office (JPO), the Federal Aviation Administration (FAA), and other Federal Government agencies coordinate WRC 605 and 606 issues in the International Telecommunication Advisory Committee Process (ITAC).  This chapter will formally define coordination, provide a methodology for assessing coordination failures, coordinating mechanisms, task dependencies, and identify alternative coordination mechanisms to produce a more effective system in coordinating U.S. government actions in the international telecommunications arena.

**Coordination Defined**

According to Crowston, "[in] coordination theory, actors in organizations face coordination problems that arise from dependencies that constrain how tasks can be performed" (Crowston, 1997: 159).  The interests and positions of the various U.S. government agencies create dependencies between actions taken by various agencies in the formation of U.S. spectrum positions.  The agency representatives must coordinate the positions across the many agencies with the goal of protecting U.S. interests as effectively as possible.

Several types of dependencies occur in spectrum management. One dependency that frequently occurs in spectrum management is a task-resource dependency, which is based on the shared use, by two or more agencies of the same bandwidth. In this example, the task is whatever the frequency is desired for, such as communicating, and the resource is the free bandwidth. One agency's actions in the bandwidth may constrain the other agency's ability to use the bandwidth by causing interference, and as a result the use must be coordinated. Continuing from this fundamental example, U.S. positions and technical contributions submitted abroad can have impact on international regulations that affect the use of spectrum, such as defining what constitutes "interference". As a result of this influence on international regulations, dependencies arise from these internationally submitted documents—a shared output dependency (listed under "task-task" in table 1). This means that a document or position that one agency desires to submit internationally is constrained by the interests of other agencies, and must be coordinated because all the agencies will be bound by the international regulations these documents and positions influence.

Coordination is defined as "simultaneously managing a flow of ongoing activities and a set of interrelated decisions" (Rathnam *et. al.*, 1995: 1903), or as "managing dependencies between activities" (Malone and Crowston, 1994: 90). These and other academic definitions share the emphasis on the managing of dependencies between activities in the furtherance of a common goal or objective (the common goal of U.S. agencies is the furtherance of the national interest). Using Crowston's terminology, "actors in organizations face coordination problems that arise from dependencies that constrain how tasks can be performed," and to overcome these coordination problems,

6

actors perform additional activities called coordination mechanisms (Crowston, 1997). An example of a coordination mechanism is a working group where conflicting positions are resolved, or a method for prioritizing interests. An example of a coordination problem would be one agency failing to account for the negative effects of a proposed regulation on another agency, perhaps resulting in a sub-optimal U.S. position.

Rathnam *et. al.*, Mahajan, and Whinston (1995) describe coordination problems as coordination gaps. They define a coordination gap in the context of customer support as "the breakdowns in the work and information flows that take place within the team during the enactment of the customer support interaction process, due to either the lack of information, the presence of incorrect information, or the excess of unusable information" (Rathnam *et. al.*, 1995: 1903). They describe the customer support process as "a business task that involves diverse team members often working together across organizational, departmental, hierarchical, and geographic boundaries" (Rathnam *et. al.*, 1995: 1900); this description is relevant to a diversity of applications; in this instance, the members of different government agencies who must work together to form a unified position. The government agencies come together to form groups with members that are geographically dispersed, and in different organizations, and as such is similar to Rathnam's customer support team.

**The Purpose of Coordination Theory**

The goal of coordination theory is simple: to define processes and improve performance, with a focus on the efficient and effective management of dependencies (Crowston, 1997). The theory enumerates two main premises that guide analysis and

7

reorganization under a coordination theory framework: the dependencies and mechanisms for managing them are general and common across many organizational settings; and, different mechanisms may be used to manage the same dependencies. Therefore, in redesigning a process, coordination problems may be identified and processes redesigned to correct these deficiencies (Crowston, 1997).

**Identifying Coordination Mechanisms**

Three main methods for identifying coordination mechanisms are: looking for activities that appear to be coordinating mechanisms, looking for dependencies between activities that require some coordination mechanism, and looking for coordination problems that suggest missing coordination mechanisms (Osborn, 1993 in Crowston, 1997). In the first step, looking for coordination mechanisms themselves, we can "examine the activities in the current process [and] identify those that seem to be part of some coordination mechanism, then determine what dependencies they manage" (Crowston, 1997: 163). Coordination mechanisms may take a variety of forms, including meetings, organizational rules, and working groups, or review processes. A working group, acting as a coordination mechanism, may be the forum where a resource is allocated to one use or another.

When looking for dependencies, we "list the activities and resources involved in the process, consider what dependencies are possible between them, and then determine how these dependencies are being managed" (Crowston, 1997: 163). Finally, for looking for coordination problems, we "can look for problems with the process that hint at unmanaged coordination problems and identify the underlying dependencies" (Crowston,

1997: 163).  Several categories of dependencies and coordinating mechanisms are

summarized in a table below (Crowston, 1997: 160):

**Table 1: Coordination Mechanisms (Crowston, 1997)**

| Dependency | Coordination Mechanism to Manage Dependency |
|---|---|
| **Task-Task dependency** | |
| **Tasks share common output** | |
| Same characteristics | Look for duplicate tasks<br>Merge tasks or pick one to do |
| Overlapping | Negotiate a mutually agreeable result |
| Conflicting | Pick one task to do |
| **Tasks share common input** | |
| (shared resource) | |
| Shareable resource | No conflict |
| Reusable resource | Notice Conflict<br>Schedule use of the resource |
| Nonreusable resource | Pick one task to do |
| **Output of task is input of other (prerequisite)** | |
| Same characteristics | Order tasks<br>Ensure usability of output<br>Manage transfer of resources |
| Conflicting | -Reorder tasks to avoid conflict<br>-Add another task to repair conflict |
| Task-resource | |
| Resource required by task | Identify necessary resources<br>Identify available resources<br>Choose a particular set of resources<br>Assign the resource |
| Resource-Resource | |
| One resource depends on another | Identify the dependency<br>Manage the dependency |

Resources are anything used by or created by tasks.  Tasks include the goals and

activities of the process.  The electromagnetic spectrum fits in the above table as a

reusable resource—one individual's use of the spectrum may preclude another individual

from using the same band (due to interference), but the resource exists unchanged after

the use ceases.  As the table above states, when conflict exists in the use of a resource, the

conflict must be recognized and then the resource use should be scheduled.  Accordingly,

one method used to coordinate spectrum use is to schedule or allocate frequencies to one

use or another.  One example of spectrum allocation is the Federal Communications

Commission's use of licenses for television and radio stations. However, there may be factors other than the coordination mechanism type contributing to coordination difficulty. Rathnam *et. al.* (1995) provide four variables that can aid in assessing these other factors.

**Variables Affecting Coordination Mechanisms**

Rathnam *et. al.* (1995) define four independent variables that describe the characteristics of the coordination (problem resolution) process. These variables aid in analyzing the cause of a coordination gap (coordination failure), and provide a framework identifying factors affecting coordination other than the dependencies and type of mechanism used. The four independent variables Rathnam et al (1995) defined as describing the characteristics of the problem resolution process are: interconnectedness, input uncertainty, interaction distances, and role conflicts (Rathnam *et. al.*, 1995: 1901). The different variables are defined as follows: interconnectedness is "the nature and extent of the one-to-many mapping between tasks and roles" (Rathnam *et. al.*, 1995: 1903), input uncertainty is "the organization's incomplete information about what, where, when, and how the customer input is going to be processed to produce desired outcomes" (Larsson and Bowen 1989: qtd in Rathnam *et. al.*, 1995:1903), interaction distances is "for a given task, the amount of communication effort required to accomplish coordination" (Rathnam *et. al.*, 1995: 1903), and role conflicts are "the nature and extent of the differences between the requirements of the tasks of the customer support team and the nature of the incentive system" (Rathnam 1995: 1904). Role conflicts represent an inconsistency between the job of an employee and their job performance evaluation, and

do not seem especially applicable in this setting. Role ambiguity (Baker and O'Brien 1971; Ahmed and Young 1974; qtd. in Rogers, 1982: 66; Griffin 1999) is a good substitute for role conflicts in this setting and represents a more general uncertainty about what priorities to put first when faced with multiple relationships. Role ambiguity represents the uncertainty about the different interests an actor represents. The inter-organizational and inter-agency context faces many of the same problems measured by Rathnam (1995), and therefore Rathnam's criteria are useful in the spectrum management setting as well. Inter-agency or inter-organizational coordination faces problems including communication (Torrens 1969; Gardner and Snipe 1970; Hooyman, 1976; qtd. in Rogers, 1982: 65), role ambiguity (Baker and O'Brien 1971; Ahmed and Young 1974; qtd. in Rogers, 1982: 66), interaction distance (Rogers, 1982: 66), and fragmentation of authority (Rogers, 1982: 66).

**Analytical Framework and Method**

By combining the work of Crowston (1997) and Rathnam *et. al.* (1995), a multi-step approach for analyzing coordination mechanisms emerges. Whereas Crowston (1997) and Crowston and Osborn (1998) applied the theory within a single organization, in this instance the theory will be applied between organizations from one perspective, or within a single organization—the Executive branch of the Federal Government—from another perspective. The application of the theory does not change, as the typologies do not change just because the organizational boundaries are re-defined. However, as the organizational boundaries are expanded, the tasks and activities will become more complex because the higher-level tasks will be the summation of many lower-level tasks.

11

The first step is to identify and analyze the coordination mechanism using one of the following approaches, where the approach is selected based upon the situation and information available: look for the coordinating mechanisms, look for dependencies, or look for coordination problems (Osborn, 1993). The second step is to look for unmanaged dependencies and other factors affecting coordination. The third step is to consider the coordination mechanisms, dependencies, and other factors affecting coordination, and identify options for improvement. While the factors that affect coordination may be defined in different ways, Rathnam *et. al.* (1995) provides four categories: interconnectedness, input uncertainty, interaction distances, and role conflicts. After the dependencies, mechanisms used (or in some cases absent), and other characteristics are identified, the process can be redesigned to correct the problem.

Data collection for this type of analysis has been accomplished in several manners, the most prominent of which include: case studies (Crowston, 1997; Crowston, 1991) and statistical sampling and surveys (Rathnam *et. al.*, 1995; Van de Ven, 1976; Roger and Whetten, 1982). Within the case study paradigm, three ways to collect information are "1) interviewing individuals, 2) examining documents that describe standard operating procedures, and 3) observing individuals" (March & Simon 1958, qtd. in Crowston 1997, 162).

**Generating Alternative Coordination Mechanisms**

*Behavioralist vs. Structuralist Schools*

According to Howard E. McCurdy (McCurdy, 1983), the macro view of coordination can be categorized into two main schools of thought, the structure and

behavior schools. The structure school emphasizes the use of organization charts, defined duties and responsibilities, systems of authority, bureaucracy, and other formal mechanisms. The behavior school emphasizes individuals, teamwork, and individual cooperation. For the structuralists, "Authority…was the source of all coordination," (McCurdy, 1983: 119) while for the behavioralists, "the job of the executive is not to stand at the intersections of the organization and shout orders, but to orchestrate the flow of traffic" (McCurdy, 1983: 127). This fundamental paradigm difference shapes the options available for coordination, and places additional constraints on the process. While the two approaches differ, they compliment each other when used together.

According to Lawler (1989), "with high interdependence [between activities], the choice is between work teams and individual approaches to work design with extensive hierarchy. In most cases, work teams are the best alternative because they are more cost effective. Low interdependence favors maximizing individual performance…" (1989: 13). Therefore, a less bureaucratic approach may be more effective in managing activities with higher interdependence.

Using the above definitions coordinating mechanisms may be categorized as behavioral or structural. These different ways of coordinating have different costs and advantages. The following chart summarizes, at a macro level, the trade-off between programming (bureaucratic methods) and informal, personal interaction (behavioral methods).

**Table 2: Summary of McCurdy (1983) and Lawler (1989)**

| Interdependence | Coordination Approach | Associated Management Perspective |
|---|---|---|
| High | Behavioral – Less Bureaucratic | Facilitate communication and teamwork |
| Low | Structure / Programming – More Bureaucratic | Define rules, responsibilities, and authority |

**Assessing Other Factors that Affect Coordination**

In addition to analyzing the task dependencies and coordination mechanisms, other factors can affect the ability to coordinate, such as distances between offices, and the complexity of the issues to be coordinated. The variables provided by Rathnam *et. al.* (1995) above provide a good framework for identifying and analyzing these other factors. Specifically, Rathnam *et. al.* (1995) discovered several attributes that make coordination more difficult. Increases in these attributes can be associated with increased difficulty coordinating. These attributes are interconnectedness, input uncertainty, interaction distances, and role conflicts or role ambiguity.

After identifying an aspect that contributes to one of these categories, the process could be redesigned to reduce the effect. For example, if large interaction distances (effort required to coordinate) are evident in a process, information technology could be used to facilitate communication through an on-line database. The interaction distance might manifest itself as repeated telephone calls required to gain access to needed information. Furthermore, Table 2: above could be applied; if the interconnectedness is low, the structured approach that dictates where official information must reside (the database), is appropriate. However, if interconnectedness is high, a database plus co-location of the actors in the same office may be appropriate. It is difficult to specify at a greater level of detail, as the corrective action will be situation-specific. Rathnam *et. al.*

14

(1995) provide several information technology initiatives that were shown to mitigate coordination problems in their survey of customer support teams (Rathnam *et. al.*, 1995). To mitigate input uncertainty, representation and reasoning about the interaction process, interaction locking (simultaneous access to information, and propagation of work performed on shared objects to the team), and process support (pre-defined work and information flows) (Rathnam *et. al.*, 1995) should be used. To mitigate interaction distances, multi-user interfaces, interaction locking, and process support should be used (Rathnam *et. al.*, 1995: 1907). Rathnam *et. al.*(1995) proposed a solution concerning interaction distances, however did not find conclusive supporting evidence for the efficacy of the solution (Rathnam *et. al.*, 1995: 1916).

**Legislation**

Federal Law establishes broad coordination requirements upon certain government agencies involved with the Global Positioning System. This body of federal law requires that the executive branch, usually by imposing a duty upon a department's secretary, include certain considerations when planning, designing, and operating the system. The primary law affecting the Global Positioning System is Title 10, Section 2281 of the United States Code. Various other acts, mainly appropriations and authorizations acts, place additional obligations on the program.

Title 10, section 2281 imposes several requirements to encourage interagency coordination. The congressionally mandated Federal Radionavigation Plan recognizes the need to coordinate across agencies. Congress requires this plan to be "prepared jointly by the Secretary of Defense and the Secretary of Transportation" (10 USC 2281).

15

Further coordination is required with the Department of Transportation on any augmentations that achieve or enhance GPS transportation uses. The Secretary of Defense must also coordinate with "the Secretary of Commerce…and other appropriate trade officials to facilitate the development of new and expanded civil and commercial uses for the GPS" (10 USC 2281). These broad guidelines show several of the interdependencies between agencies regarding the Global Positioning System.

The Federal Radionavigation Plan "serves as the planning and policy document for all present and future Federally provided common-use Radionavigation systems" (Department of Defense and Department of Transportation, 2000: 1-1). Several Memorandums of Agreement (MoAs) between the Departments of Defense and Transportation, and the Interagency GPS Executive board (IGEB) influence the production of the Radionavigation plan. The IGEB is a formalized high-level policy and planning organization that encompasses numerous governmental agencies. The memorandums recognize, on behalf of the two departments, the need to coordinate navigation planning and utilize common systems wherever possible (Department of Defense and Department of Transportation, 2000: 1-1). A Presidential Decision Directive created the Interagency GPS Executive board. It is the permanent interagency forum designed to manage GPS and U.S. Government augmentation to GPS.

Specific to spectrum management, public law 105-303 (Oct 28, 1998) states that the president should "provide clear direction and adequate resources" so the Department of Commerce can "achieve and sustain efficient management of the electromagnetic spectrum used by the Global Positioning System; and protect that spectrum from disruption and interference" on an international basis. This law also directs other broad

coordination between the DoD designers, planners, and operators with the Department of Commerce.

An executive order, Presidential Decision Directive NSTC-6, established the Interagency GPS Executive Board (Department of Defense and Department of Transportation, 1997). The departments of Agriculture, Transportation, Defense, Commerce, Interior, Justice, NASA, and State participate through the IGEB in management and use of the system.

## III.    Methodology

**Overview**

This research used a case study method structured by coordination theory to guide the analysis and data collection.  The subject of the study was spectrum management with a focus on the Global Positioning System and World Radio Conference resolutions 605 & 606.  The primary sources of data were interviews with members of the Global Positioning System Joint Program Office (JPO) located in El Segundo California, Federal civil agencies located in the Washington D.C. area, and corroborating documentation, when available.  Finally, the analysis of the data was conducted using the theory framework described in this chapter and chapter two.

**Case Study Methodology**

The methodology was a single-case study design analyzing the spectrum management process.  The spectrum management process involves many agencies and organizations throughout the U.S. government.  This process provides an opportunity to assess a specific example of interagency coordination.  Furthermore, this assessment would help improve the interagency processes involved in Global Positioning System spectrum management.

Case studies can be used to accomplish various goals: "to provide description (Kidder, 1982), test theory (Pinfield, 1986; Anderson 1983), or generate theory (e.g., Gersick 1988; Harris & Sutton, 1986)" (qtd. in Eisenhardt, 1989: 535).  This case study falls in two categories, to provide description and to generate theory.  In the first instance,

this case study will provide a description of the interagency spectrum management process, as it applies to the Global Positioning System.  Secondly, this case will use coordination theory to assess how well the process is functioning.  Additionally, the method used to assess the process offers a roadmap for the examination and improvement of other interagency processes.

**Limiting the Scope of the Research**

When examining the Global Positioning System Program, many interagency processes could be examined.  This study was limited to one interagency process—the GPS spectrum management actions related to the 2000 World Radio Conference (WRC) resolutions 605 & 606.  This agency-spanning process was identified and chosen based upon three criteria: importance, dysfunction, and feasibility (Hammer, 2001: 127).  The criteria serve two purposes: to ensure that the process will illustrate the difficulties inherent in interagency coordination, and to select a process that would benefit significantly through the application of coordination theory.  The GPS spectrum management actions related to resolutions 605 & 606 were chosen because of their high importance, the high feasibility of examining them, and the apparent dysfunction of the process.  Furthermore, it is not the purpose of this study to assess the correctness of any agency's decision in a particular instance.  Instead, the study intends to identify problems and suggest ways to make the coordinating process work more efficiently based on a theoretical analysis.

**Data Collection**

The data was collected through eleven interviews and supporting documentation. The interviews were conducted over several months, through multiple site visits to the various organizations, telephone calls and electronic mail. Generally, the individuals interviewed were personally involved in the process. The documents were collected to support the interviews. When an item of interest was identified in an interview, documentation was sought both to confirm what was stated in the interview and to provide additional information.

All data sources have the potential for error. Interview data faces several problems including bias, poor recall, and poor or inaccurate articulation (Yin, 1984). When pertaining to established facts, confirming documents mitigate this source of error (e-mails, memorandums, official documents). When confirming documents are not available, multiple interview sources are used (Yin, 1984). Documentary sources may face similar problems concerning inaccuracy or bias (Yin, 1984). This source of error is mitigated when the document is corroborated, states an official position, is published by an official body, or is subject to a review process. However, combining these sources gives greater credibility. As Eisenhardt (1989) states, "[t]he triangulation made possible by multiple data collection methods provides stronger substantiation of constructs and hypotheses" (Eisenhardt, 1989: 538).

Data collection was accomplished in two steps. In the first step, the objective was to identify interagency processes. To accomplish this, many individuals were interviewed to solicit general information about the interagency processes. The appendices contain the interview guide that was used during the unstructured interviews.

The first stage interviews were only used to identify processes that could be investigated, and not for analysis (appendix B).  Once this preliminary information was collected, one process was selected using the criteria of importance, feasibility, and dysfunction (as described above).  After this first round of interviews, the spectrum management process was identified and chosen for analysis.  Appendix C lists some of the other identified processes, some of which may be suitable for future research.  The second stage of data collection focused on spectrum management.  In-depth information particular to spectrum management was gathered from multiple sources and perspectives, including interviews from representatives of the Federal Aviation Administration (FAA), Joint Program Office (JPO), National Telecommunications and Information Administration (NTIA), Air Force Frequency Management Agency (AFFMA), Interagency GPS Executive Board (IGEB) Secretariat, and a non-government spectrum management consultant.  From this information, the process was mapped, dependencies revealed, and problems examined.

**Data Analysis**

The data was analyzed using coordination theory as described in the literature review (Chapter II). Coordination theory provides the framework for looking at interagency coordination. The basic steps include (adapted from and using: Crowston 1997; Crowston and Osborn 1998; Crowston 1991; Malone and Crowston, 1994; Rathnam *et. al.*, 1995):

1) Identify the Coordination Mechanisms
   Identify the dependencies
   Verify the model of dependencies and/or coordination mechanisms
2) Look for unmanaged dependencies and identify other factors affecting coordination
3) Identify problems and options for improvement

*Identify the Coordination Mechanisms*

In the spectrum management process, the coordination mechanisms are easily identified, and as a result, the process is well suited to an analysis that focuses on the coordination activities, such as working groups, study groups, and approval processes (Crowston and Osborn, 1998: 23, Crowston, 1997: 163). This type of analysis is called an activity-focused analysis (Crowston and Osborn, 1998: 23, Crowston, 1997: 163). In this type of analysis, the focus is to "identify coordination mechanisms, then search for dependencies…identify activities in the process that appear to be coordination activities, then ask what dependencies those activities manage" (Crowston and Osborn, 1998:23). In the case of GPS Spectrum Management, the analysis would begin with the coordination mechanisms, which are the various committees, and proceed to see what dependencies those activities manage.

It is critical that the model of mechanisms and dependencies be correct. To assess the validity of the model, experts in the field will review the model and multiple sources of information will be used (Yin, 1984: 36).

*Look for unmanaged dependencies and identify other factors affecting coordination*

An unmanaged dependency is one where a dependent relationship exists, yet there is no mechanism to coordinate it (Crowston, 1997: 168). Unmanaged dependencies can be identified by looking for coordination problems (Crowston, 1997: 168). An example of such a problem would be the lack of a process to manage the constituents' needs (such as a review board), or a mechanism that does not match the type of dependency to be managed (the review board does not have adequate authority).

Identifying other factors affecting coordination involves looking at outside factors such as the distance between the parties or complexity of the task. It may be useful to assess these other factors using Rathnam's (1995) variables. This may be useful because the fundamental conditions of interagency coordination (see Rogers, 1982) are similar to those in Rathnam's study (see Rathnam *et. al.*, 1995).

*Identify Problems and Options for Improvement*

The first two steps used to analyze data should reveal problems within interagency coordination and areas for improvement. The exact nature of the improvement initiatives should suit the particular situation and problem. Care should be taken to ensure that all dependencies are addressed, and that any intervening factors (such

23

as distance) are addressed.  For example, if the intervening factor is distance, then the solution should address the need to be located closer together.

**Validity Threats**

Four main types of validity threats affect the credibility of this study.  These include threats to construct validity, internal validity, external validity, and reliability (Dooley, 2001).  While validity threats are difficult to assess in qualitative research (Dooley, 2001), several techniques do exist to address these concerns.  The table below summarizes the validity threats (Yin, 1984) and the method used to mitigate the validity threat.

Table 3: Validity Threats

| Validity Threat | Applicability | Mitigation Technique |
|---|---|---|
| Construct Validity | Correct identification of coordination mechanisms and dependencies. | Use multiple sources of data to confirm or disaffirm; Establish a chain of evidence; Have key informants review draft report |
| Internal Validity | Correct analysis of coordination modes and problems. | Application of coordination theory framework (explanation-building) |
| External Validity | Generalizability of findings to other GPS program interagency processes. | Identify common traits between processes (out of scope); Use Replication (out of scope) |
| | Ability to generalize to other interagency programs. | Identify elements common to interagency programs (out of scope) |
| Reliability | Data collection methods | Document method and processes; Use protocol |
| | Analysis | Document analysis framework and criteria, assumptions |

*Construct Validity*

Construct validity is defined as the extent to which the measure reflects the intended construct (Dooley, 2001: 342) or establishing correct operational measures for the concepts being studied (Yin, 1984: 36). Several techniques were used including multiple sources of evidence, establishing a chain of evidence, and having key informants review the findings to ensure the correct assessment of dependencies, actors, and processes.

*Internal Validity*

Internal validity is defined as "truthfulness of the assertion that the observed effect is due to the independent variables in the study" (Dooley, 2001: 346), or "establishing a causal relationship…as distinguished from spurious relationship" (Yin, 1984: 36). Coordination theory, as defined and described in chapter 2, helps ensure internal validity. The conclusions rest upon the careful application of the logic developed by the experts in the fields. In turn, confidence in the logic developed by the experts combined with the correct application, lends credibility to the results.

*External Validity*

External validity is defined as "generalizability of the study's findings to other populations, places, or times" (Dooley, 2001: 345) or "establishing the domain to which a study's findings can be generalized" (Yin, 1984: 36). The best way to assess external validity is by "repeating the study with different subjects, in different situations and places, and at later times," (Dooley, 2001: 272) which is outside the scope of this study. Another method to assess external validity is through analytical generalization, which

focuses on the similarities between situations, and how well the theory applies to other situations (Yin, 1984: 39). This study has several tenets similar to other interagency circumstances, which will be addressed in chapter five.

### *Reliability*

Reliability concerns ensuring that the operations of the study can be repeated with the same results (Yin, 1984: 36). The documented process and references should aid in replication of this study by allowing future researchers to validate and use the same model. Furthermore, the study should be repeatable by other researchers using the same analytical framework and theory.

# IV. Data Collection And Analysis

## Introduction

As stated in the methodology (Chapter III), coordination problems may reveal unmanaged dependencies (Crowston, 1997: 168). This approach, where the analysis begins at the "problem" proves very useful in this instance. The individuals working issues related to WRC resolutions 605 and 606 in the interagency process have experienced great difficulty coordinating technical contributions, and to a lesser degree proposals / views, with other agencies (Interview with FAA Spectrum Manager; Interview with JPO Spectrum Manager; Interview with Spectrum Consultant).

Unfortunately, simply knowing that difficulty exists does not illustrate where the root problem or cause of the difficulty is—it merely indicates that something may be wrong. These difficulties in the interagency process provide an excellent starting point from which to begin the analysis. Crowston states we "can look for problems with the process that hint at unmanaged coordination problems and identify the underlying dependencies" (Crowston, 1997: 163). Following this approach, the analysis first looks at the point in the process where the difficulties illustrate a potential problem. Subsequently, coordination theory guides the analysis through the process searching for the cause of the difficulty.

To begin the analysis, it is first important to understand the context and the interagency structure within which these issues are coordinated. A detailed explanation of the World Radio Conference preparatory process is provided below, focusing on those areas pertinent to the problem introduced above. Following the explanation of the

process, the coordination analysis proceeds in an attempt to ascertain the cause of the difficulty and identify ways to improve the process. Furthermore, as stated in chapter III, this study looks for ways to improve the process and not assess the decisions of any particular agency or individual.

**The U.S. Domestic World Radio Conference Preparatory Process**
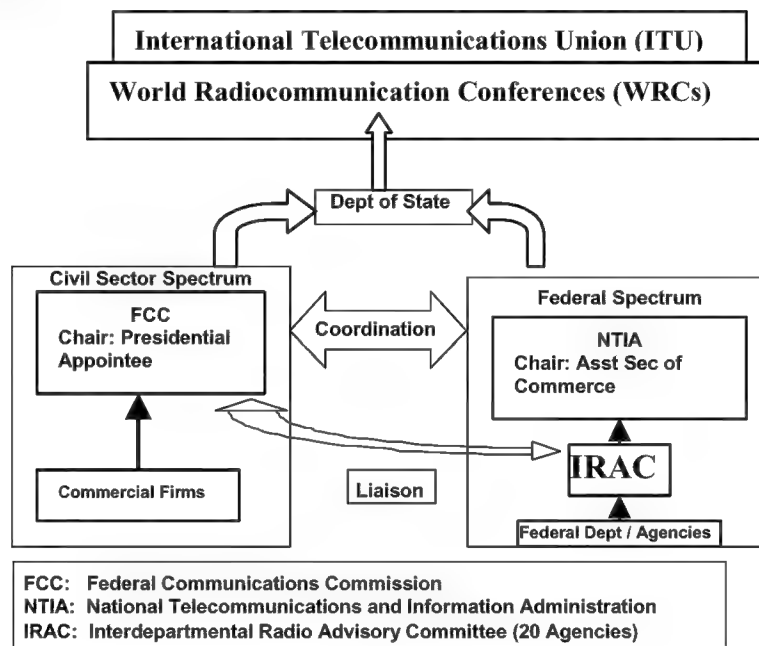


**Figure 1: Domestic Spectrum Management Process (adapted from U.S. Gov. Slide)**

As shown above, the electromagnetic spectrum is managed in two separate structures: The National Telecommunication and Information Administration (NTIA) manages the spectrum for Federal agencies, and the Federal Communications Commission manages the spectrum for all other users (NTIA Spectrum Manual, 2001). The Department of State acts as the U.S. representative to international spectrum regulatory bodies and treaty organizations, such as the International Telecommunication Union (ITU). On matters that require international participation, the process participants

advise the State Department under a structure called the International Telecommunication Advisory Committee (ITAC) and U.S. delegations. Through this structure U.S. positions are created and supporting technical work, studies, and proposals are approved and submitted internationally.

For government users, the spectrum management process usually begins in individual government agencies or their departments. Spectrum management actions may be necessary in response to spectrum management developments or new program needs. Issues may be international, domestic, or both, involving policy and technical questions. The domestic issues are primarily handled by the NTIA, FCC, or both, depending on the nature of the issue. International issues are handled through ITAC.

## The International Telecommunications Advisory Committee Process

U.S. preparations for the World Radio Conferences consist of two different types of products (Interview with NTIA Spectrum Manager, Spectrum Management Consultant). The first type of product is a policy document, which is called either a preliminary view, draft proposal, or proposal, depending on which stage in the process the document is drafted. The preliminary view is an early position while a proposal is a more mature position on any given issue. The second type of document is a technical document. These technical documents, also called contributions, are submitted to ITU working parties and other international bodies. These submissions should provide the specific scientific, technical, and regulatory support for the existing positions or view, and are submitted to preparatory meetings at regular intervals in the time between conferences. Hence, one of the goals of this work process is to form the technical basis

internationally for the U.S. position on a given issue.  The figure below shows the process

for creating U.S. proposals / views and the supporting technical work.

Figure 2: ITAC Process

International Rules and Regulations

Output

Foreign Interests

Foreign Inputs

Foreign Proposals

ITU working-group meetings, regional meetings, Conference Prep. Meeting

U.S. Technical Papers & Proposals

National Committee
State: Chair
FCC, NTIA: Co-chair

World Radio Conference

U.S. Positions

State Department

Proposed Technical Contributions

Study Groups

SG1  SG2  SG3  SG4  SG5  SG6  SG7  SG8  SG9  SG10  SG11

Study Groups are groupings only and do not require separate approval

IGEB WG3

The IGEB WG3 acts as informal coordination only

WP8A  WP8B  WP8C  WP8D  WP8E  WP8F

GPS Technical Work

NTIA

IRAC

RCS

Federal Government Interests

FCC

WAC

IWG-2

Private Sector Interests

GPS Policy Work
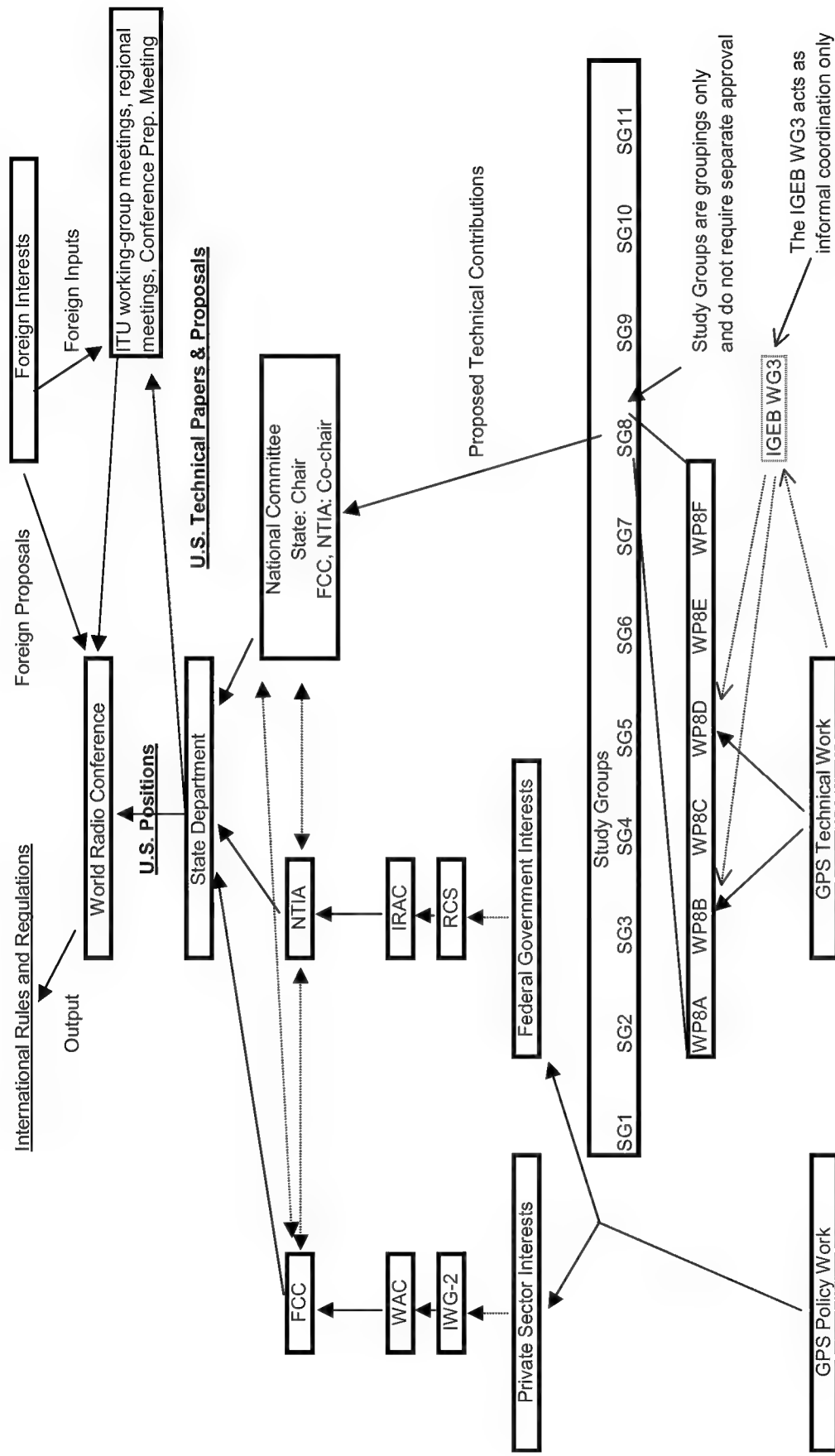
31

As indicated in figure one, the Department of State handles the U.S. participation in international telecommunications treaty organizations, such as the International Telecommunication Union (ITU). The International Telecommunication Advisory Committee process (ITAC) advises the Department of State in this role, and includes all of the committees, subcommittees, and groups in figure 2 whose output feeds into the Department of State (the FCC and NTIA are not themselves committees, but agencies that host committees). "ITAC aids in the preparation of U.S. positions for meetings of international treaty organizations, develops and coordinates proposed contributions to international meetings and submits them to the Department of State for consideration" (ITAC, 2001). Members of ITAC include "representatives of government and operating agencies, as well as scientific or industrial organizations involved in the telecommunications sector" (ITAC, 2001). The ITAC process is divided into several areas, including radiocommunication (ITAC-R), telecommunications (ITAC-T), and telecommunication development (ITAC-D). GPS spectrum issues fall under the radiocommunication sector, or ITAC-R (ITAC, 2001).

For ITAC-R, U.S. positions are formed in the committees as indicated in figure 2. Policy submissions enter the process on the left, into their respective federal (NTIA) or civil (FCC) process. The FCC and NTIA proposals are merged to form official U.S. proposals (Interview with NTIA Spectrum Manager). Contributions (technical papers) proceed through the working parties on the right side of figure 2. The ITAC-R technical approval process is sub-divided into study groups and working parties according to areas of responsibility. Within the ITAC-R technical approval process, Study Group 8 has responsibility for mobile, radiodetermination (radar), and related satellite services. The

study groups are groupings of the working parties and do not play an independent role. U.S. Working Party 8D is a sub-unit of Study Group 8, and has responsibility for the Radionavigation Satellite Service (RNSS). U.S. Working Party 8B, also a sub-unit of SG8, has responsibility for radiolocation and radiodetermination issues. The Global Positioning System is a Radionavigation Satellite Service (RNSS). Accordingly, most GPS World Radio Conference issues are worked through U.S. Study Group 8, U.S. Working Party 8D (Radionavigation Satellite Service), and to a lesser degree U.S. Working Party 8B (Radiolocation). Any interested party may join the U.S. Working Parties (Interview with JPO Spectrum Engineer).

The ITAC-R National Committee is the approval body for all technical contributions submitted internationally to the ITU, regional spectrum bodies, and preparatory meetings held by the ITU. The Department of State chairs the ITAC National Committee in consultation with the Vice Chairs, NTIA & FCC. The committee chair, in consultation with the vice-chairs, has final approval authority. Although the National Committee considers both unapproved and approved items, the committee will generally only approve items approved by the Working Parties. The Working Parties approve items on a consensus basis of interested government and industry participants (Interview with GPS Spectrum Engineer; Interview With FAA Spectrum Engineer, 2001; International Telecommunications Advisory Committee).

In the case of GPS, most technical actions and resulting contributions originate in the Joint Program Office (Interview with JPO Spectrum Manager, Interview with FAA Spectrum Manager, Interview with NTIA Spectrum Manager). These actions include studies, analyses, simulations, tests, and proposed regulatory mechanisms. These actions

are documented, and the documentation must be approved through the technical approval process of the U.S. International Telecommunication Advisory Committee (for Radiocommunications) Process (ITAC-R) before being submitted internationally to the ITU.

**Selected Process Participants**

*The International Telecommunication Union (ITU)*

The International Telecommunication Union (ITU) is a specialized agency affiliated with the United Nations (ITU History Online), of which the United States is a member. The Union exists to promote telecommunications standards and resolve telecommunications issues worldwide. The ITU holds World Radiocommunication Conferences (WRCs), which are treaty conferences that require formal proposals and delegations under the U.S. Department of State. These conferences are "the means by which the world distributes the resources of the radio-frequency spectrum" (U.S. Congress, Office of Technology Assessment, 1991: 9). The final acts of WRCs have international treaty status, and as such are generally adhered to by all 190 ITU member countries (U.S. Congress, Office of Technology Assessment, 1991: 9-10). The ITU also holds numerous preparatory meetings where WRC participants discuss issues and formulate positions (Interview with JPO Spectrum Engineer). These meetings occur at regular intervals leading up to the WRCs (JPO Briefing, Interview with JPO Spectrum Engineer). Technical papers and proposals are presented and discussed at these meetings, laying the foundation for eventual WRC negotiations (Interview with JPO Spectrum Engineer).

The United States must be able to forcefully advocate and support its positions on radio-frequency spectrum in the international arena. "The lack of a unified radio-communication policy, including international spectrum goals, will hurt the United States' ability to negotiate and compete globally" (U.S. Congress, Office of Technology Assessment, 1991: 3). The technical contributions that support the policy (and are a type of narrow policy statement in themselves) require the same unity and cohesiveness to achieve maximum effectiveness. The ITU holds the meetings that are the main international forum where global spectrum policy and regulations standards are established.

*National Telecommunication and Information Administration (NTIA)*

The National Telecommunication and Information Administration (NTIA) is "an agency of the U.S. Department of Commerce (DoC), [and] is the Executive Branch's principal voice on domestic and international telecommunications and information technology issues" (NTIA, 2001). The NTIA has ultimate authority in managing the spectrum for Federal users (Roosa, 1994). Within the NTIA, The Office of Spectrum Management (OSM) is responsible for managing the Federal Government's use of the radio frequency spectrum (NTIA, 2001).

The Interdepartment Radio Advisory Committee (IRAC), which the NTIA chairs, assists "the Assistant Secretary [of Commerce] in assigning frequencies to U.S. Government radio stations and in developing and executing policies, programs, procedures, and technical criteria pertaining to the allocation, management, and use of the spectrum" (NTIA Web, 2001).

IRAC's Radio Conference Subcommittee (RCS) prepares for ITU radio conferences, including the development of recommended U.S. Proposals and Positions for the WRC. The RCS positions are merged with Federal Communications Commission (FCC) WRC Advisory Committee (WAC) positions to form a united US position on a given agenda item. Both RCS and WAC are in coordination on a regular basis throughout the process so the proposals & positions that are developed are usually mostly in accord with each other (Interview with JPO Spectrum Engineer 2001; Interview with Expert Spectrum Consultant 2002; Interview with NTIA Spectrum Manager 2002).

*Federal Communications Commission (FCC)*

The Federal Communications Commission (FCC) is an independent U.S. Government Regulatory Agency established by Congress in the Communications Act of 1934 (FCC Web, 2001). The FCC regulates "domestic and interstate and international communications by radio, television, wire, satellite and cable" (FCC Web, 2001). "The FCC's jurisdiction covers the 50 states, the District of Columbia, and U.S. possessions" (FCC Web, 2001). The FCC represents non-government users in the spectrum management process. The World Radio Conference Advisory Committee (WAC) advises the FCC on preparations for the World Radio Conference (FCC WAC WEB Documents, 2002). Interim Working Groups (IWGs) deal with specific issues as delegated by the WAC (FCC WAC Web Documents, 2002). Private sector participants can offer draft proposals through the industry working groups (Interview with spectrum consultant).

*Interagency Global Positioning System Executive Board (IGEB)*

Presidential Decision Directive (PDD) NTSC-6 established the Interagency GPS Executive Board (IGEB) as a permanent body to manage GPS policy and U.S. Government augmentations to GPS. Of particular importance, the IGEB Charter states that part of the Board's function is to "approve management issues that affect dual-use" and "resolve interdepartmental issues" for the benefit of GPS (Department of Defense and Department of Transportation IGEB Charter; JPO Spectrum Manager). An inter-agency working group on spectrum issues, IGEB-WG 3, has been established under the IGEB body. IGEB Working Group 3 is "focused on the protection of spectrum used by the Global Positioning System (GPS) and its augmentations" (Department of Defense and Department of Transportation IGEB-WG 3 Charter). Members of the IGEB and of IGEB-WG 3 include DoD, DoC, DoT, NASA and other agencies (Department of Defense and Department of Transportation IGEB Charter; Department of Defense and Department of Transportation IGEB-WG 3 Charter). The IGEB and IGEB-WG 3 exist to rectify multi-agency GPS issues, however the body does not have any official authority and has not been influential in the national spectrum management process.

*Air Force Frequency Management Agency (AFFMA)*

The Air Force Frequency Management Agency (AFFMA) is an agency of the Air Force responsible for supporting Air Force frequency management needs. The Agency supports a wide range of programs, including space, ground, and airborne systems. The Agency is located in the Washington, D.C. area, and is in close contact with other frequency management organizations (Interview with AFFMA Manager, Jan 11 2002).

*Federal Aviation Administration (FAA)*

Within the FAA, the Office of Spectrum Policy and Management, known as ASR, represents the United States in ITU meetings and in the International Civil Aviation Organization (ICAO) (FAA Web, 2001). ASR also provides the U.S. member to assist the ICAO in formulating ICAO positions on various frequency management issues. ASR is active in the World Radio Conference preparation process (FAA Web, 2001).

The Spectrum Planning and International Division of ASR (ASR-200) focuses on providing for and protecting the radio frequency spectrum required to support civil aviation communications, navigation, and surveillance services. This division has responsibility for technical and engineering issues regarding civil aviation functions. In accomplishing its responsibilities, ASR-200 is involved in extensive studies and technical preparation (FAA Web, 2001).

*International Civil Aviation Organization (ICAO)*

The International Civil Aviation Organization (ICAO), an agency of the United Nations, was created by international agreement in 1947 (International Civil Aviation Organization, 2001). ICAO's responsibilities include "maintaining co-ordination with the International Telecommunication Union [ITU] on all matters concerning the electromagnetic spectrum allocated to the aeronautical communications, radio navigation and surveillance services and administering the use of these allocations" (International Civil Aviation Organization, 2001). ICAO's recommendations have considerable influence on ITU member countries and the aviation community. As a result, ICAO plays a role in shaping the international opinion regarding resolutions 605 and 606.

Currently, "the ICAO position is to support a single maximum aggregate interference limit [PFD limit] for all RNSS systems operating in [L5]" (Capretti and Witzen, 2001: 29).

**Overview of Domestic Agencies' GPS Roles**

The chart below outlines some of the ITAC members' GPS-related roles as defined in the 1999 Federal Radionavigation Plan, Presidential Decision Directive, or Public Law.

**Table 4: Agency GPS Responsibilities**

| Party | Responsibility | Reference |
|---|---|---|
| Department of Defense | Global Positioning System | March 29, 1996 Presidential Decision Directive; 1999 Federal Radionavigation Plan, A-2 |
| Department of Commerce | Global Positioning System Spectrum and Commercial Applications | Public Law 105-303 |
| DOT / FAA | Civil Application of Global Positioning System | March 29, 1996 Presidential Decision Directive; 1999 Federal Radionavigation Plan, A-5 |
|  | Manage interference testing in the GPS Spectrum to prevent disruptions to service. | 1999 Federal Radionavigation Plan, 3-9 |
| Department of State | Oversight of interagency review process | March 29, 1996 Presidential Decision Directive; 1999 Federal Radionavigation Plan, A-10 |

**World Radio Conference 2003 Resolutions 605 and 606**

At the 2000 World Radio Conference, European efforts resulted in the approval of resolutions 605 and 606 (agenda item 1.15), which the United States opposed (Schoettler,

2001: 48, 49). These resolutions stated a need to consider power flux density limits on the L2 and L5 frequencies of the Global Positioning System (Schoettler, 2001: 48, 50), as well as future Radionavigation Satellite Systems (RNSS). GPS satellites transmit navigation data to the GPS receivers on the L2 and L5 bands. The limits are based upon the theory that GPS Satellite transmissions can interfere with Radars and Distance Measuring Equipments (DME's), which have been assignments in the L2 and L5 bands respectively.

The United States Air Force GPS Joint Program Office (JPO) has been conducting technical work to either substantiate or refute the theory that GPS transmissions will interfere with incumbent systems. In the case of the L2 band, there have not been any reports of interference to radars in the 23 years that GPS has been in operation. The GPS L5 band will not start transmitting until 2005 and will not be fully operational until 2016.

Such limits would directly affect the $1.2B GPS modernization and are undesirable to the United States for several reasons. U.S. forces depend upon GPS technology, and the successful jamming of current and weaker GPS signals would be harmful to U.S. operations, and could place U.S. troops at risk. A high-powered or focused GPS signal is an effective countermeasure to jamming. The PFD limits restrict the power of GPS signals, and therefore increase the system's susceptibility to jamming. Non-military uses of GPS are also susceptible to malicious or inadvertent interference, which a high-powered signal would help overcome. A higher-powered civil signal will also maximize the availability of signal at any given point on Earth, thus improving GPS

reliability and utility.  In fact, the L5 civil signal is designed to be more powerful than the current L1 civil signal.

Resolutions 605 and 606 will inhibit the Global Positioning System modernization program.  Future and unforeseen national security interests or civil applications may require more powerful signals.  Once international rules on power restrictions become permanent, changes to these rules will require international agreement.  If the restrictions could not be lifted, the system's development would be constrained.

There are several reasons besides the claim of interference why foreign countries could desire to place power flux density limits upon the Global Positioning System.  First, some foreign governments could find themselves in a military confrontation with the United States, and lower power levels would make jamming GPS signals easier.  Secondly, the European Union is developing a rival satellite navigation system called Galileo.  Placing PFD limits upon the satellite navigation frequencies limits the U.S. system, but has no effect on the yet un-fielded European system.  The limits would inhibit the development of the U.S. system, which might help a rival European system to gain acceptance in the future.  Otherwise, with unbridled development, the American system may so far exceed a European system by the time it is operational, that the European system may never gain acceptance.  Finally, any adversary of the United States might support a restriction that limits the American system, when the country itself does not have such a system and is not affected.

The veracity of these theories is not important to the conclusions of this study; it is only important that plausible motivations other than claims of interference exist for

limitations on radionavigation satellite transmissions. These other plausible motivations increase the need for the United States to present a coherent and persuasive position to the international community.

**GPS Spectrum Defense Efforts**

The United States Air Force GPS JPO has taken action to protect the GPS spectrum including technical studies, analyses, simulations, tests, developing regulatory mechanisms, and conducting outreach efforts to other countries (Department of the Air Force WRC-03 Plan). The U.S. proposals for Resolutions 605 and 606 have been developed and state the U.S. positions. The U.S. position for Resolution 605 is a coordination procedure whereby the RNSS operators will coordinate to provide protection to incumbent systems and retain the flexibility to modernize and build future RNSS systems. The U.S. position for Resolution 606 is that no PFD limit is needed (U.S. Preliminary View). Technical analyses are performed in conjunction with policy formulation to ensure that correct policy has been selected, and is demonstrated as fact to the international community. As such, the results of the technical studies and tests are contributions to the WRC preparatory meetings and ITU, and should support the existing U.S. position. In order to submit papers internationally, they must be coordinated and approved through the ITAC-R Technical Approval Process.

**Consensus-Based Coordination**

Crowston's typology, as shown in chapter two, states that when activities share a common output, and that output is overlapping, a mutually agreeable result should be negotiated; when the tasks conflict, one task should be chosen to do (Crowston 1997).

The various activities performed by the different actors in the technical approval process share a common output; in other words, anything that is submitted internationally is considered to be submitted by the United States Government, and not any individual agency. All of the documents and positions come together (a shared output) in the U.S. negotiations at the World Radio Conference. As such, the individual agencies should be in concurrence with a document when it goes international. The domestic process is organized to ensure that result. All agencies and even private sector participants can provide input into the ITAC process, and voice disagreements where appropriate. In the technical approval process, the government and industry participants work together in the same committees and working groups. In the proposal generating process, the private sector interfaces with the FCC and Federal government agencies interface with the NTIA.

In the ITAC process, the task dependencies are often overlapping, and a mutually agreeable result can be negotiated. This means that including one party's concerns does not affect or conflict with including those of any other party. An example of such an occurrence would be if one agency requires "A" or "B", and another agency requires "B" or "C", such that the agencies could negotiate to perform "B"—a mutually agreeable (and efficient) result. A consensus-based process works well for this type of situation.

The second possibility for activities with a shared output is that the tasks will conflict. This means that including one party's concerns will affect or conflict with including those of any other party. One such example would be if one agency would benefit from a regulation and another would be harmed by the same regulation. While there may be some middle ground where each agency gets part of their objectives met, any solution will involve a trade-off. A consensus-based process, by definition, does not

have the ability to make this trade-off decision if the parties will not agree. The consensus process is susceptible to negotiation tactics by parties acting in their own best interest, desiring to obtain a more favorable outcome. Consequently, the outcome may be the sub-optimal trade-off between individual agencies' interests strongly influenced by bureaucratic power.

**WRC 605 and 606 Technical Work Coordination**

Unfortunately, the technical work surrounding WRC 2000 resolutions 605 and 606 is among the minority of issues where a mutually agreeable result is not easily obtained. With conflicting interests, agencies may consistently disagree about the methodology used in a study, the conclusions to be drawn from an analysis, and many other aspects of technical work. Agencies would disagree because certain methodologies, technical definitions, and conclusions would change their ability to protect their agency's interests presently or in the future.

Such is the case with technical work surrounding WRC Resolutions 605 and 606. The table below summarizes the interests of the various parties. The main players in the 605 and 606 issues are the Air Force and the FAA. The other parties listed also play a role, but are not extensively involved.

**Table 5: Agency Perspectives**

| Agency | Position / Perspective | Reference |
|--------|------------------------|-----------|
| FAA | • Brings awareness of ICAO's perspective to ITAC process <br> • Protect aviation systems <br> • DME's have priority over GPS as a "safety of life" application | FAA Web, 2001 Interview, FAA Spectrum Engineer, December 4, 2001 |
| AF/GPS (JPO) | • Protect GPS system against adverse regulation, i.e. PFD limits and "excessive" international oversight. <br> • GPS modernization and future applications will require more power. <br> • Testing and analysis has not shown any need for PFD for resolution 606 and developed coordination mechanisms for resolution 605 to satisfy both RNSS and ARNS systems | Interview with GPS Spectrum Engineer: 19 December, 2001 |
| AFFMA | • Must represent all Air Force spectrum interests <br> • Need to stay on amicable relations with other D.C. located spectrum offices in order to maintain ability to negotiate. | Interview with AFFMA Spectrum Manager: 11 January 2002 |
| NTIA | • NTIA does not have the resources to get involved in interagency disputes related to WRC resolutions 605 & 606. <br> • NTIA has not played as active a role in these (WRC 605 & 606) issues as they could have. <br> • NTIA views many issues as interagency squabbles. | Interview with NTIA Spectrum Manager |

The above table illustrates the diversity of perspectives the involved parties hold.

These divergent and fairly noncompatible views between the Air Force and the FAA

begin to show why coordination by consensus would be difficult between these parties.

Furthermore, the perspectives of the other parties contribute to coordination difficulty.

The unofficial perspective presented within NTIA explains why that agency has not taken

an active role in the coordination.

The perspective presented from AFFMA hints at a problem within the Air Force

in presenting a consistent approach on these issues based on the different views of and

priority given to the same spectrum issue. ICAO's role further complicates the issue due to FAA's relationship with ICAO, and ICAO's relationship with the international aviation community.

The specific problem exists between the GPS spectrum interests and the FAA's concerns regarding Distance Measuring Equipment (DMEs). The FAA uses DMEs (JPO Spectrum Engineer), and as a result, the FAA has a reason to support interpretations favorable to DMEs when coordinating issues related to WRC resolutions 605 and 606. The JPO desires unrestrained use of RNSS spectrum for the reasons outlined above.

The Global Positioning System Joint Program Office and FAA have conflicted on the nature of U.S. technical papers and positions submitted to the ITU regarding these matters (JPO Spectrum Engineer; FAA Spectrum Engineer; Spectrum Consultant Expert). The FAA has opposed the JPO authored papers within U.S. Working Party 8D. The language in the papers has been diluted to achieve consensus, usually weakening the asserted position (JPO Spectrum Engineer).

The difficulty in presenting papers stems from two issues coordinated in ITAC-R, especially Working Party 8D. "[T]he FAA's goal is to approve Satnav [GPS] as the only radionavigation system required to be installed in an aircraft to support operations anywhere in the NAS [National Air Space]" (Department of Defense and Department of Transportation, 2000: 3-27). However, the FAA also currently operates and will continue to operate DME (Distance Measuring Equipment) for backup aircraft navigation (Department of Defense and Department of Transportation, 2000: 3-27). The PFD limits sought by the Europeans were based upon the theory that GPS signals would interfere

with radars / DMEs (Schoettler, 2000: 51), and the ongoing discussions center around this interference issue.

Both the FAA and JPO have expressed the continual difficulty and aggravation surrounding these issues. Some FAA employees involved in working these issues have expressed that it has been very difficult to reach agreement. They have expressed that the issues have been confrontational between the agencies (FAA Spectrum Manager), that there is no arbiter of the preparatory process, that it is get consensus or do not go, and that no one is looking out for what is best for the U.S. as a whole (FAA Spectrum Manager). Employees at the JPO have expressed similar views or concurred with these opinions (JPO Spectrum Manager).

These divergent interests between the FAA and JPO surrounding WRC resolutions 605 and 606 make consensus-based coordination problematic. The FAA has pursued a strategy in line with their interests, which is to advocate measures that would benefit their DME's systems (FAA Spectrum Manager). However, this strategy is in direct conflict with the GPS JPO interests. The NTIA has not provided overall guidance or leadership in resolving these issues, but instead has played a facilitator role encouraging the parties to achieve consensus (NTIA Spectrum Manager; FAA Spectrum Manager; JPO Spectrum Manager). The ITAC-R national committee could provide the leadership necessary to resolve conflicts. However, they generally act only as facilitators (AFFMA Technical Manager; JPO Spectrum Manager).

As a result, the current approach is to fight out the issue bureaucratically or give in to compromise when the other party is successful in blocking your action (NTIA Spectrum Manager; FAA Spectrum Manager; JPO Spectrum Manager). Agency

representatives have raised issues to higher levels within their department when consensus cannot be reached.

This situation has a striking similarity to observations made in a 1991 Congressional Office of Technology Assessment report. This report stated that with no clear leadership, the process "depends on the power of individual personalities and the personalities among major players" (U.S. Congress, Office of Technology Assessment, 1991: 101). The goal of the process is to reflect the best interests of the U.S. government, not to be unduly influenced by the power of individual players. As a result of this system, some submissions and alterations to technical contributions are more influenced by agency interests than focused upon supporting the existing U.S. position. Subsequently, the technical submissions may not support the existing position as strongly as they could.

**Other Factors Affecting Coordination**

Several other factors make coordinating these issues exceptionally difficult. These factors include interaction distances, interconnectedness, and role ambiguity. Interaction distances refers to the effort required to coordinate (Rathnam *et. al.*, 1995; Torrens 1969; Gardner and Snipe 1970; Hooyman, 1976; qtd. in Rogers, 1982), interconnectedness refers to the degree of interrelationships between the tasks (Rathnam *et. al.*, 1995), and role ambiguity refers to the degree to which individuals represent multiple interests (Baker and O'Brien 1971; Ahmed and Young 1974; qtd. in Rogers, 1982: 66; Rathnam 1995: 1904-1905).

The interaction distances are high due to the geographic separation of the FAA and JPO, as well as other agencies. The FAA spectrum office is located in Washington, D.C., and the GPS Joint Program Office is located in Los Angeles, CA, three time zones apart. Face-to-face meetings and discussions require a lengthy flight across the country. Conference calls and teleconferences face the difficulty of a three-hour time difference. The program office can attend many meetings in Washington D.C., but finds it extremely difficult to maintain an active presence. The other co-located Washington, D.C. agencies should find it easier to meet and reach agreements that do not include the JPO's considerations. The JPO and GPS interests should, however, have a presence in D.C. through the Air Force Frequency Management Agency.

Role ambiguity plays a minor role in the process; however, several instances of role ambiguity are pertinent. First, the FAA works closely with ICAO on an interpersonal level and is thereby influenced by ICAO to an uncertain degree (Spectrum Consultant Expert; NTIA Spectrum Manager). Thereby, ICAO may influence the FAA, bringing non-U.S. interests into the process. Secondly, AFFMA, as the JPO's representative in the D.C. area, has to represent numerous Air Force issues in addition to GPS, and is co-located with the other agencies. Subsequently, when negotiating one of many issues with the other agencies, AFFMA has to balance the interests of different systems (AFFMA Technical Director), may trade off one system's priority in negotiations for another, and as a result may not give the JPO as much support or priority as the JPO desires.

The high levels of interconnectedness are caused by the nature of the technical work being performed. The technical work often requires extensive coordination between the FAA and JPO.

The primary difficulty in coordinating these issues stems from the use of an improper coordination mechanism—a consensus-based process. The use of a consensus-based process to coordinate directly conflicting issues by coequal process players results in interagency power struggles and solutions that may not reflect the national interests (as defined by the existing U.S. view or proposal). Coordination is complicated to a lesser degree by interaction distances, interconnectedness, and role ambiguity. Among these three (interaction distances, interconnectedness, and role ambiguity) interaction distances seems to have the largest impact due to the three-hour time difference and large geographic separation of the JPO and FAA.

## V.     Conclusions And Recommendations

As described previously, the ITAC process acts to integrate the many interests of U.S. agencies and private sector participants. Within this process, proposals or views and supporting technical documents are approved for international use. In many occasions, coordinating the interests of different parties or agencies simply means incorporating the various interests into the document. However, with certain issues, incorporating one agency's interests must come at the expense of another agency's interests. For these issues, a consensus-based process becomes a power struggle. Accordingly, an examination of resolution 605 and 606 issues in the ITAC process revealed several propositions regarding consensus-based coordination processes:

**Theoretical Conclusions**

The application of coordination theory to the interagency coordination process revealed several propositions:

1. A consensus-based coordination process is adequate for: activities that share a common output, and that output is overlapping. A consensus-based process is suited to issues that do not directly conflict, and where a mutually agreeable result is negotiable.

2. A consensus-based coordination process is not adequate for: activities that share a common output, and the tasks conflict. In this instance, a mutually agreeable result is not easily obtained.

   a. When conflicting tasks are coordinated through a consensus-based interagency process, agency power struggles will ensue.

i. The result of such a power struggle will be in line with the agency having the most authority, influence, or resources.

b. When tasks conflict, there needs to be a mechanism separate from the two coequal parties, such as an independent decision-maker, to decide what takes priority.

**Specific Conclusions concerning GPS spectrum / regulatory issues**

In addition to the theoretical aspects, this study sought to identify the situation-specific problem or problems in coordinating ITU contributions (especially technical papers) relevant to WRC resolutions 605 and 606 within the U.S. government. Defending and advancing U.S. interests at the ITU requires submitting the results of technical efforts in the form of technical contributions. The problem is that changes to technical contributions are allowed that are strongly influenced by interagency power struggles and thereby not necessarily consistent with or supporting of the existing U.S. position. Changes that are influenced by agency interests instead of supporting the existing U.S. position weaken the United States' ability to support its spectrum positions internationally. Increased involvement of leadership in approval process of technical contributions may mitigate this problem.

The logic behind these specific findings is outlined below. First the premises or base assumptions are listed. The premises are followed by important findings of fact. The conclusions are determined from an analysis of the facts using coordination theory and the premise as the desired state or goal.

*This study assumes the following premise:*

1. Any technical contribution submitted internationally to the ITU should support the existing U.S. position.

    a. The term "U.S. position," as used above is defined to mean the existing U.S. view / proposal on the given issue.

    b. The term "technical contribution submitted internationally" refers to those technical contributions created within the U.S., and approved by the ITAC National Committee.

*This study makes the following findings of fact:*

1. Changes to technical contributions are being made that are inconsistent with the existing U.S. view / proposal or simply weaken the argument.

    a. One or more agencies are making these changes that are seen as favorable to their agency's interests; examples of these changes are a more favorable interference methodology or wording of a paper's findings.

*This study makes the following conclusions:*

1. There is insufficient oversight and enforcement to ensure any changes to technical submissions are consistent with the existing U.S. view / proposal or unnecessarily weaken the argument.

2. Although an agency may disagree with the existing view or proposal for its own reasons, they must act as if in agreement with that policy in the technical approval process.

3.  The geographical separation between the GPS JPO and Washington D.C.-based

    Federal Agencies increases the effort required to coordinate.

**Suggested remedial actions:**

Below are suggested actions, along with their potential advantages and disadvantages.  The suggested actions may be combined or used individually.

Action:  Have the NTIA assume a more aggressive leadership role to ensure all internationally submitted technical work and changes thereto are in strict compliance with the existing U.S. view or proposal.

Advantages:  The NTIA is already the principal Federal Government spectrum manager.  Under a more proactive leadership role, the NTIA could influence the Federal Agencies, set overall spectrum goals, and ensure a cohesive effort.

Disadvantages:  The NTIA may need increases in budget and work force to assume a greater level of detail in the process.

Action:  Use the existing U.S. view or proposal on a given issue as a benchmark by which to settle disagreements between agencies and parties on input documents.

Advantages: No structural changes to the process are required.  Process participants will no longer feel compelled to compromise on issues and lengthy controversies and arguments could be avoided.

Disadvantages:  This approach gives additional weight to the existing U.S. view or proposal, and could cause difficulties in changing it if evidence becomes available to necessitate that.

Action: Create a GPS-JPO field office in the Washington D.C. area directly under the control of the Joint Program Office.

Advantages: The JPO will have a greater attendance at the frequent spectrum-related meetings that occur in the D.C. area, and the JPO representatives can develop personal relationships with other agencies' D.C. based employees. The personal relationships will facilitate teamwork and communication, and the geographical location of the individuals will reduce the effort required to attend meetings.

Disadvantages: The most obvious drawback is the additional expense. Additionally, unless actions are taken to reinforce the connection of the D.C. based office with that in Los Angeles, the goals and vision of the geographically separated offices may drift apart.

**Limitations of Findings**

This research focused on the technical contributions created and submitted in response to WRC 2000 resolutions 605 and 606. While the conclusions of this study should be applicable to this specific example, there may be other factors that prevent the conclusions from being generalized to the process as a whole. Additionally, while the views of many different agencies and experts were incorporated in the study, other pertinent perspectives may not have been considered.

**Future Research Topics**

1. The IGEB charter states that, among other responsibilities, it exists to "approve management issues that affect dual-use" and "resolve interdepartmental issues"

(Department of Defense and Department of Transportation IGEB Charter; JPO Spectrum Manager). Assess the IGEB's ability to perform these functions.

2. Assess the individual government agencies' buy-in to the IGEB, their willingness to resolve disputes there, and willingness to accept the decisions.

3. The Interagency Forum for Operational Requirements exists to generate civil requirements for the Global Positioning System. Coordination is required to integrate the civil and military, obtain funding, and make trade-off decisions. Ineffective coordination can result in unmet or unstated requirements. Preliminary indications show insufficient performance accountability between the IFOR and civil requirement process. Assess the effectiveness of the IFOR process.

4. Identify the factors that make coordinating a multi-agency program difficult. Suggested case studies include NPOESS (National Polar Orbiting Environmental Satellite System), the Global Positioning System, and the newly created Homeland Security Office.

# Appendix A: Acronyms

| | |
|---|---|
| AFFMA | Air Force Frequency Management Agency |
| ARNS | Aeronautical Radionavigation System |
| CITEL | Inter-American Telecommunication Commission |
| CPM | World Radio Conference Preparatory Meeting |
| DME | Distance Measuring Equipment |
| DoD | Department of Defense |
| FAA | Federal Aviation Administration |
| FCC | Federal Communications Commission |
| GPS | Global Positioning System |
| ICAO | International Civil Aviation Organization |
| IGEB | Interagency GPS Executive Board |
| IGEB-WG3 | Interagency GPS Executive Board Working Group 3 |
| ITAC | International Telecommunications Advisory Committee |
| IRAC | Interdepartment Radio Advisory Committee |
| ITU | International Telecommunications Union |
| IWG | Interim Working Group |
| JPO | (The Global Positioning System's) Joint Program Office |
| NAS | National Air Space |
| NASA | National Air and Space Administration |
| NTIA | National Telecommunications and Information Administration |
| OTA | U.S. Congress Office of Technology Assessment |
| PFD | Power Flux Density |
| PV | Preliminary View |
| RCS | Radio Conference Subcommittee |
| RNSS | Radio Navigation Satellite Systems |
| SG | Study Group |
| WAC | World Radio Conference Advisory Committee |
| WP | U.S. Working Party |
| WP8B | U.S. Working Party 8B |
| WP8D | U.S. Working Party 8D |
| WRC | World Radio Conference |
| WRC 2000 | World Radio Conference held in the year 2000 |

# Appendix B: Interview Guide for Preliminary Interviews[1]:

Hello Sir / Ma'am:

I am researching interagency coordination between the DoD component of the Global Position System and the Civil agencies. I am looking for specific examples of activities that require interagency coordination, how these processes function, and the problems or successes inherent in these processes.

Use one of these approaches, depending on the particulars of the example given (if the example involves coordination mechanisms, use the activity focused approach; if the mechanisms are not obvious, use the dependency-focused approach)

Dependency-Focused analysis: Identify dependencies, then search for coordination mechanisms. In other words, look for dependencies, then ask which activities manage those dependencies. Failure to find such activities might suggest potentially problematic unmanaged dependencies.

In dependency-focused analysis, we examine the activities and the resources they use, determine possible dependencies by considering which resources are used by more than one activity and then look for other activities within the process that manage these dependencies. More specifically, to identify dependencies and mechanisms, we ask questions such as the following about each activity in turn:

·What are the inputs to this activity (physical, informational, and other preconditions such as permissions? Are there flow dependency with the activities that create these resources? Are these resources used by other activities, creating shared resource dependencies?

·What are the outputs? Is there a flow dependency with the activities that use these resources? Do multiple activities create these resources, creating common output dependencies?

·What other resources are used, e.g., actors, resources, or other items of importance in the process? Are there shared resource dependencies with these resources? How are these resources assigned to this activity?

Activity-focused analysis: Identify coordination mechanisms, then search for dependencies. In other words, identify activities in the process that appear to be coordination activities, then ask what dependencies those activities manage. This approach asks if the coordination activities are necessary or effective.

Two main heuristics: 1) Search directly for coordination activities. Identify tasks and see what they coordinate. Identify shortcomings in the coordination activity. 2) Identify individuals that coordinate. Identify what they coordinate, and how the coordination takes place.

Possibilities for areas to examine:
> Specifications that multiple agencies rely upon
> Documents that multiple agencies rely upon
> Requirements involving more than one agency

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[1] This guide was used to gather preliminary information about a process and determine if the process was a good candidate for analysis.

# Appendix C: Preliminary Process Identification[2]

**Processes analysis working sheet:**

| Process "Name" | Dysfunction, Importance, Feasibility (High, Medium, Low) | | Notes and Characteristics |
|---|---|---|---|
| Spectrum Management | H | | The GPS program complies with international electromagnetic frequency allocations. As a result, the program must represent its interests in a domestic and international setting. The GPS spectrum management process operates through several organizations including the U.S. Working Party Process, the IGEB, International Telecommunications Union, CITEL, and The International Civil Aviation Organization, and others. These organizations work to coordinate the multitude of positions within the U.S. Government, regions, and the world. |
| | H | | |
| | H | | |
| Document approval and publication, ICDGPS705 (currently draft) | M | | The L5 Specification is given to a contractor, (in this case ARINC) to write the Interface Control Document → document then undergoes a JPO internal review → the document is send to the DoT for review, and an iterative process with the DoD to come to a consensus on the document's contents. |
| | L | | |
| | M | | |
| SPS Spec and Guaranteed Performance levels | M | | Drafting and publishing these specifications involves a multitude of organizations (and their sub-organizations), including the DoT, DoD, FAA, RTCA, and others. Pay attention to mismatches in documents and performance parameters. |
| | H | | |
| | L | | |
| SV19 End of Life Test, non-routine | M | | FAA affiliated Stanford professor working on WAAS determined need to conduct a test on GPS satellite. Test had to be coordinated across multiple agencies, including 2nd Space Operations Squadron (AF), JPO, and FAA/DOT. No individual owned process or had responsibility for overall process. NOTE: Test did not take place due to unrelated reasons. |
| | L | | |
| | H | | |
| Non-routine issue, test of GPS satellite for interference. | M | | 2nd Space Operations Squadron, OO-ALC-LH (Hill AFB Radar Squadron) 124 & 117, also coordinated with the FAA; FAA did not approve, and Air Force researched legal ramifications and indicated to FAA that it was not part of the process. FAA agrees. Coordination was accomplished along mainly informal modes. |
| | L | | |
| | H | | |
| IFOR and DoD Acquisition Milestone Process | M | | The Interagency Forum for Operational Requirements exists to generate civil requirements for the Global Positioning System. Coordination is required to integrate the civil and DoD requirements, fund, and make trade-off decisions. Ineffective coordination can result in unmet or unstated requirements. Preliminary indications show insufficient performance accountability between the IFOR and civil requirement process. |
| | H | | |
| | L | | |
| IGEB as a coordination mechanism | M | | The IGEB operates to coordinate many interagency aspects of GPS. Investigation could asses this effectiveness. Preliminary indications indicate problems with a consensus decision-making format. |
| | H | | |
| | L | | |

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[2] Note: this table is the result of only a *preliminary* investigation; the descriptions are not developed, and the list is not exhaustive. This is only provided to illustrate some of the processes.

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Abstract: At the 2000 World Radio Conference (WRC), a European initiative resulted in the approval of resolutions 605 and 606 (agenda item 1.15), which the United States opposed. These resolutions established provisional power flux density (PFD) limits on the L2 and L5 frequencies of the Global Positioning System. These limits will negatively affect the $1.2B GPS modernization. The United States will have to present its positions and rationale regarding the PFD limits to international meetings, including the 2003 World Radio Conference, to persuade the international community to adopt the U.S. view. Preparations for the WRC are accomplished through a domestic interagency U.S. process called the International Telecommunications Advisory Committee (ITAC) process. In this process, the interests and efforts of numerous agencies must be coordinated to produce a focused and cohesive argument. Several players in the ITAC process working issues surrounding WRC resolutions 605 and 606 have encountered considerable difficulty reaching agreement and submitting technical contributions internationally. An analysis of the ITAC process using coordination theory reveals that the problem stems from coequal participants attempting to coordinate directly conflicting interests in a consensus-based process, complicated by the geographic separation of the parties.

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